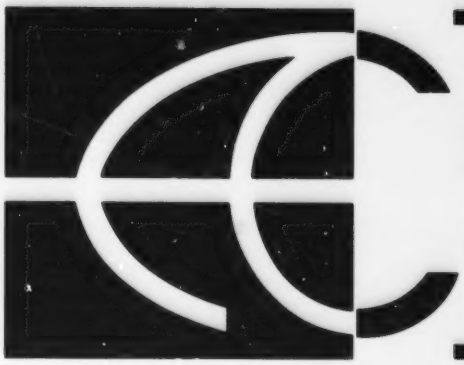

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89-01135/

MICROPROCESSOR ENVIRONMENTAL CONTROL IN A LARGE FARROWING COMPLEX

Report No. 88-3301 September, 1988

This demonstration/evaluation project was partially funded by the Ontario Ministry of Energy and managed by the Agricultural Energy Centre of the Ministry of Agriculture and Food.

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Guelph, Ontario
N1H 6N1

MICROPROCESSOR ENVIRONMENTAL CONTROL IN A LARGE FARROWING COMPLEX

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Cooperators:

Chris and Nancy Cockle
Heronbrook Farm Ltd.
R.R. #3
Embro, Ontario
N0J 1J0

By:

Ralph G. Winfield, P.Eng.
Energy Engineer
Agricultural Energy Centre
Ontario Ministry of Agriculture and Food
Box 666
Woodstock, Ontario
N4S 7Z5

MICROPROCESSOR ENVIRONMENTAL CONTROL

IN A LARGE FARROWING COMPLEX

INTRODUCTION

The need for improved control of environmental adjustment mechanisms, namely exhaust fans and heaters, has long been recognized. The sensing elements and switching components of traditional gas or liquid filled thermostats are prone to corrosion in harsh environments. Over time the calibration of individual units tend to drift or the dead band widens resulting in a loss of desired control.

Control loss can allow improper sequencing or undesirable overlapping. The results are often significant ventilation rate cycles in cold weather which cause rapid temperature fluctuations, and/or excess ventilation while supplemental heat is being provided. The latter scenario can cause significant waste of purchased heat energy as electricity, propane, natural gas or whatever fuel is being used in heat deficient animal housing units.

Recent technological developments have given rise to microprocessor control systems. These systems can sequence heating/cooling functions according to a preprogrammed schedule using only one sensor for an

environmental space (room) rather than the traditional three to five. The main control (switching) components can often be remotely located in a clean air space with only the sensor(s) remaining in the harsh environment.

OBJECTIVES

The objectives of this demonstration project were:

1. To evaluate the direct energy savings potential attributable to a more sophisticated control system.

2. To determine the cost effectiveness of an initially more expensive control system vs the maintenance costs associated with thermostat replacements.

3. To determine the improved productivity benefits resulting from better environmental control as well as managerial benefits of having more readily available data resulting from being able to adjust control programming more easily.

4. To assist manufacturers in developing microprocessor technology for the agricultural market and to evaluate the reliability of that equipment in a relatively hostile environment.

THE FARROWING COMPLEX

The Heronbrook Farm Ltd. swine farrowing complex was chosen as a demonstration site because of energy efficient integrated physical facilities, excellent management capabilities, and good performance records.

A single building 18 290 mm by 99 060 mm (60 x 325 ft) houses 300 sows, all the weanling pigs to 25 kg, as well as growing rooms for replacement gilts. There are fifteen separate pig housing rooms requiring individualized environmental control conditions plus a heated central hallway, utility room and office area. Figure 1 is a schematic of the total farrowing complex.

The building is of concrete sandwich wall construction, oriented north south, with a solar collector/storage wall on the south end (Ref. Winfield, 1981). A wall-type heat exchanger on part of the west side recovers exhaust heat from the two weanling rooms and three of the four hot nurseries (Ref. MacDonald, 1985). All the prewarmed air from the heat exchanger and the solar wall is delivered to the central hallway at the south end of the building. The hallway acts as the fresh air source for the entire farrowing/weanling section of the facility.

All additional heating energy is provided by electricity. Fan-forced heaters are located in the hallway to provide additional air tempering to 7.2°C (45°F) as well as in all four hot nurseries and the two larger

weanling rooms. Controlled output heat lamps are used for creep heating (12 farrowing crates per room) in all five farrowing rooms. During farrowing up to three 250 watt lamps per sow might be in use. Immediately following farrowing the number of operable lamps is reduced to one per crate (sow and litter). Various automatic output control systems have been tried. The most common control mechanism in use is the manual three position (Off-Low-High) switch on individual heat lamps.

The breeding room, gestation area, and both gilt growing rooms are full building width and require no supplemental heat. Air movement in these wide rooms is enhanced with fan and perforated tube systems. In addition the breeding area has an evaporative cooling pad system in the east wall for summer air temperature suppression.

THE MICROPROCESSOR CONTROL SYSTEM

In late 1986 the cooperators chose to install a prototype control system being developed by Roth Electric (now Tavi Energy Co.) of Tavistock, Ontario.

The initial proposal was for one master unit with programming capabilities to operate the required 15 slave units – one for each room or animal housing space. Each slave unit would in fact be a 'smart board' that could retain the programmed information even during malfunction of the master unit. (This 'fail safe' feature was and must remain a concern

of potential suppliers/users of microprocessor control systems.)

The control system was amended during installation in early 1987. As installed the system consists of one major control unit located in the office area. The control unit is made up of five master boards each capable of being programmed to control the exhaust fans, heaters and inlets (louvres) of three rooms. The programmer (a dedicated keyboard with printer) can be directed to any one of the five master boards to adjust temperature action levels or print temperature in any of the three rooms (see Figure 2). The system also incorporates alarm functions to inform of a temperature over or under preset limit values, power outage and has the capacity for monitoring water pressure, etc.

One shortcoming of the present system is that preprogramable temperature adjustments are not possible. For example downward temperature adjustments in the hot nurseries must be inputted each time. Secondly an alarm condition must be sought by addressing the master boards individually. And thirdly, an automatic printout of all room temperatures is not possible.

On the positive side, the system has been reliable to date with only minor gliches affecting one board and thus three rooms. Resetting is relatively simple.

To date the supplier has provided excellent backup support often with

simple instructions over the phone. No 'handbook' or 'operators manual' has been produced.

The installed cost of the system including the control wiring and relays was $14,900.00

DATA ACQUISITION

The farrowing complex is served from a 75 kVA, 575 volt, 3-phase service, thus the additional cost of metering individual heaters and fans was deemed to greatly outweigh the possible benefits.

Since the farm has monthly meter reading/billing it was decided to compare average daily consumption (kWh/day) and monthly demand set (kW) as an overall comparative measure of the influence of the microprocessor control system in the swine farrowing complex.

Unfortunately the farm service also supplies power to one residence and small cattle feeding enterprise on the site. However, both of these power users are relatively small and consistent and thus should not mask a significant impact on the major electrical power use in the farrowing complex.

Figure 3 shows energy consumption and demand for three successive

winter periods. All demand values are shown but customer charges only occur for demands over 50 kW.

The cooperator also provided information on operational problems and overall pig performance. Unfortunately, a disease outbreak in early 1987 caused a temporary reduction in pig throughput during the summer frustrating any specific comparisons of pig performance immediately before and after the system was installed.

Ongoing changes in other management areas have also contributed to improved pig performance, i.e. days to market, during the longer evaluation period.

RESULTS

Better temperature control was obtainable in the critical heated areas – primarily the four hot nurseries. It should be noted that temperature control was variable for a period of time in January and February of 1988 when temperature recording was planned. It is believed that ammonia was deteriorating the silicone sealant on the temperature sensors permitting them to absorb moisture. The sensors were covered with rubber sleeves by the supplier in late spring which corrected the varying temperature problem. Unfortunately this delay allowed outside temperatures to become too high for meaningful inside (room) temperatures to be recorded.

Basically the cooperators are happy with the system as installed. It is doing what they wanted – providing better temperature control. They are convinced the weaned pigs are performing better as a result. Their veterinarian has also commented on the improved condition of the weanling pigs.

The system to date has been reliable with no major outages as a result of lightning surges, power failures etc. The unit is self protected by a capacitor system to control minor surges and has an eight hour internal battery backup. (As would be expected the farrowing complex has a self contained standby power unit with automatic power switch on 30 second outage delay and 15 second engine warm-up.)

The other minor operational problems have resulted from rodent (mouse) damage to control circuit wiring. All internal building walls are of concrete block, thus, no problems were anticipated where the control and sensor wiring bundles penetrated these walls. However, this was not the case. The wiring bundles were later protected by PVC tubing and a professional rodent service employed.

Figure 3 data indicate some reduction in energy (kWh) consumption during the 'off peak' heating period. It must be remembered that the control system was not fully operational until May 1987 and that the reduced energy usage in Nov. and Dec. of 1987 when compared to 1986 might be partially due to the temporary reduction in stocking density following disease

recovery. In contrast the Jan. thru April 1988 energy consumption was slightly higher than for the same period in 1987 and 1986. Total consumption for the Oct. through March winter periods of 1986-87 and 1987-88 are essentially the same with 1985-86 being only 4% higher. It is however interesting to note a modest reduction in recorded monthly peak demand during May, June and July when we compare before (1986) with after (1987 and 1988) installation of the controller. Apparently during partial heating load conditions the improvement of control is able to marginally improve 'load factor'. When the heaters are cycling frequently or not allowed to force overventilation, they do not cumulatively sustain demand for the necessary 20 minute set time. With 1988 demand charges of $4.80/kW, over 50 kW, for the 3-phase service a reduction of 2 or 3 kW becomes a desirable benefit. (The demand charge for a single phase service is presently $2.56/kW - reducing the potential benefit somewhat.)

The very small direct energy use reductions were not unexpected for this well managed farrowing complex. A comparison of energy consumptions in two totally enclosed (fan ventilated) broiler houses, one having microcomputer control, as reported by Allison and McLendon (1988) support this finding. They found that with well managed facilities the computer controlled house required more fuel energy than did the conventionally controlled house.

COOPERATOR VIEWS IN RETROSPECT

They are basically satisfied with the prototype control system. It

is providing better temperature control than had been available with the recent multi-thermostat system that was in place.

In the seven years of building use prior to controller installation the cooperators believe that most thermostats were changed twice in continuing efforts to maintain desirable temperature control. At the time of the controller installation they estimated that a $3000 'rethermostat' project was the alternative action to upgrade performance.

While they view an even more sophisticated control system as being in the 'nice-to-have' category, they do not plan to upgrade. The supplying company, while providing excellent support, is not continuing development of the control system for the agricultural market at the present time. (The company is working extensively in the industrial sector.) (Other companies/suppliers are presently offering more specialized controllers in the agricultural sector – for a price.)

The Cooperators two most desired controller enhancements would be: a) the capability to preprogram a temperature program for a pig housing cycle; b) the capability for intermittent room temperature printouts to support observations or trends when doing feed trials/comparisons etc.

Weaner pig productivity in the complex has increased significantly since the microprocessor control system was installed. The average time

from parturition to an average weaning weight of 25 kg. has decreased from 69 to 61 days and the total days to market from complimentary growout facilities has decreased from 192 to 168 days. However, the cooperators are cautious about allocation of these improved productivity figures as many other management related changes have also been made during this controller evaluation period. As with any field evaluation project, maintaining a 'one effect' comparison (control) is virtually impossible.

CONCLUSIONS

1. Total direct energy usage rate in this swine farrowing complex has been maintained or reduced slightly while pig productivity has been increased. Thus, a net energy saving per unit of productivity has been achieved.

2. Electrical demand (kW) has been reduced a nominal amount in most months. This is desirable for the cooperator and the power supplier.

3. The unit under evaluation performed as well as expected. Minor modifications required should aid the manufacturer in future development efforts. For example low voltage control wires must be protected from rodents and sensors must be well sealed.

4. Cost effectiveness is very difficult to assess. Better environmental control is only one segment of a <u>total</u> management package. We started

with excellent management and it got better. The cost/benefit ratio contributed by the microprocessor control system in this installation cannot be segregated out – unfortunately.

5. It is very possible, that comparable control systems installed in less well managed farrowing complexes, might show more significant reductions in direct energy usage. However, most of the reduction could probably be attributable to other system/management changes that were necessary to allow the control system to perform effectively.

6. Reliable, sophisticated environmental control systems are becoming more readily available. Many of these systems provide additional management information capabilities. It is the need for this information and the prior assurance that the environmental adjustment equipment inplace, or to be purchased, can indeed be controlled to provide the desired environmental conditions that must be considered before purchasing any sophisticated control systems.

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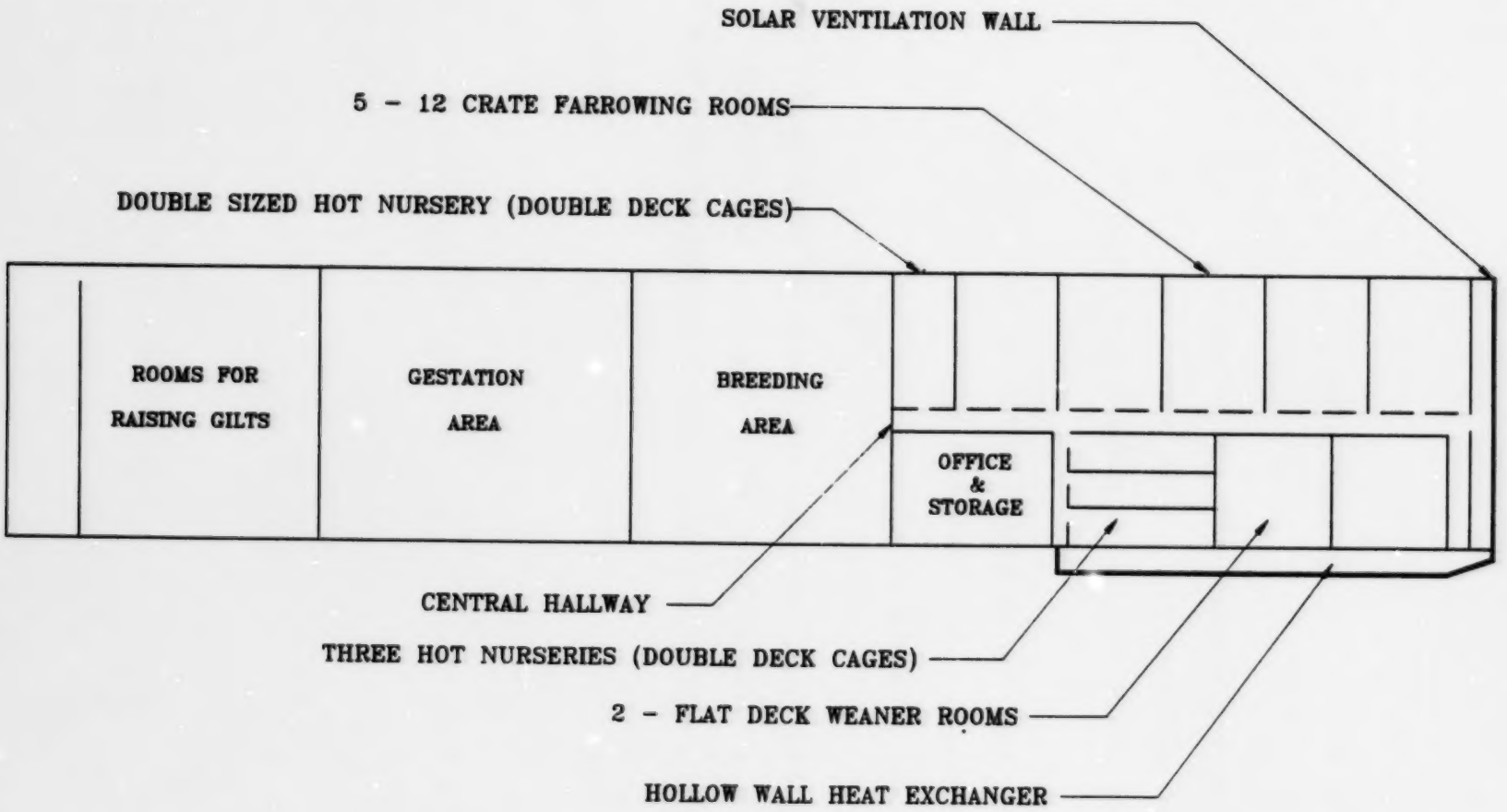

SOLAR VENTILATION WALL
5 - 12 CRATE FARROWING ROOMS
DOUBLE SIZED HOT NURSERY (DOUBLE DECK CAGES)
ROOMS FOR RAISING GILTS
GESTATION AREA
BREEDING AREA
OFFICE & STORAGE
CENTRAL HALLWAY
THREE HOT NURSERIES (DOUBLE DECK CAGES)
2 - FLAT DECK WEANER ROOMS
HOLLOW WALL HEAT EXCHANGER

Figure 1 Schematic of Heronbrook Farm Ltd. farrowing complex

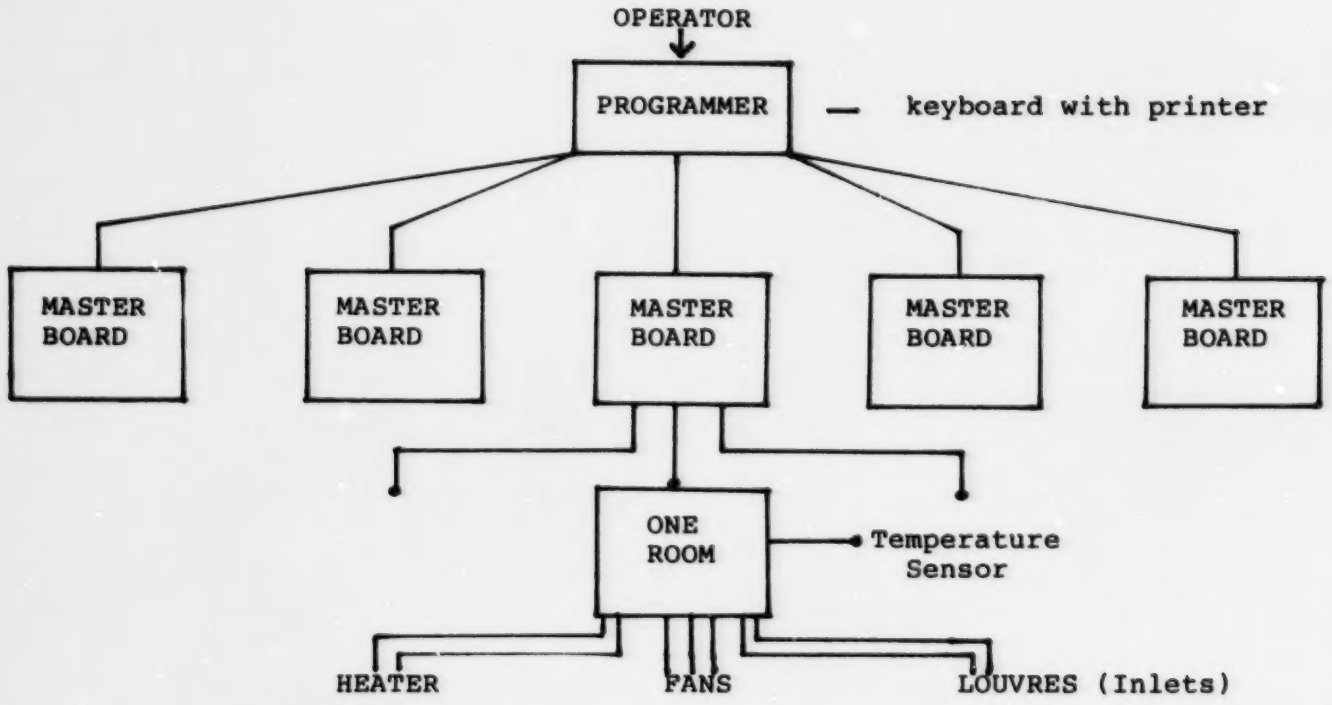
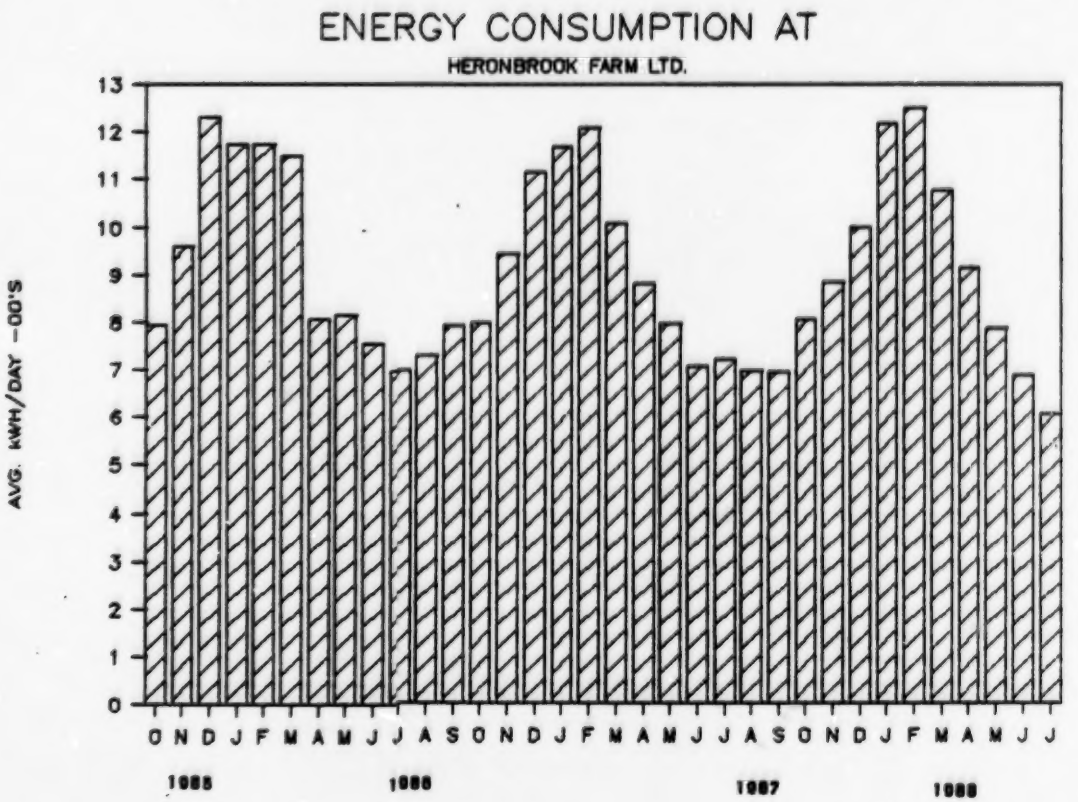


Fig. 2 Schematic of microprocessor control system installed at Heronbrook Farm Ltd.



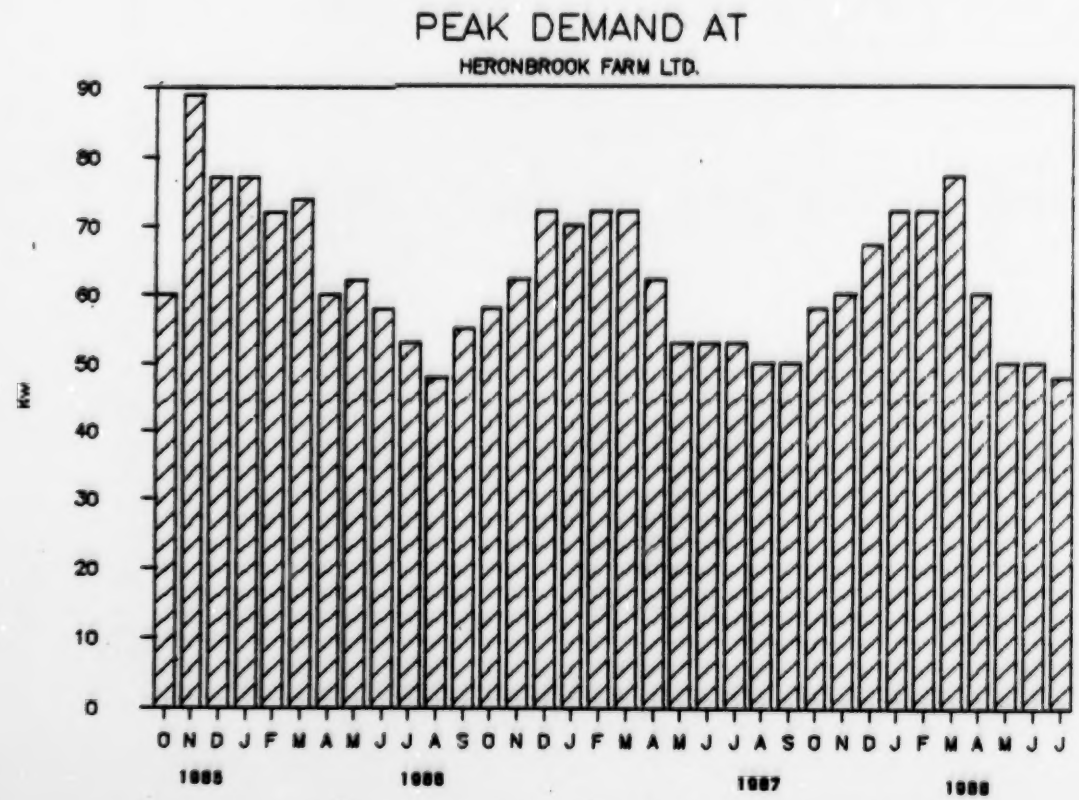


Figure 3 Energy consumption and demand profiles.

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